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Program - Project - Job: **US - LHC DFBX**

Title: **DFBX Shipping Specification**

1. Introduction

LBNL is currently designing the eight DFBX feedboxes as part of the Large Hadron Collider (LHC). The boxes will be shipped to CERN in Switzerland for installation in the LHC beamline. Each feedbox will be shipped in its own fully enclosed crate that will provide adequate shock and vibration protection as well as environmental control. This document specifies the design requirements that must be met by the shipping crates based on the geometry of the hardware and the expected acceleration loads for the given mode of transportation. The DFBX fabrication vendor shall be responsible for the design and fabrication of the crates and for arranging and coordinating the shipment of the boxes to CERN per the requirements set forth in this document and according to the schedule specified in the RFP Statement of Work.

2. Shipment Description

Each DFBX feedbox consists of a 1.25" thick stainless steel shell with a cryogenic tank suspended within it along with a series of pipes and high current leads. The eight boxes are comprised of six unique but similar designs as shown in the following LBNL top-level assembly drawings: 24C350, 24C351, 24C352, 24C362, 24C394 and 24C395. Figure 1 shows an image of a 3D model of one of the boxes along with its overall dimensions. Each feedbox weighs a total of approximately 13,000 lb. The location of the center of mass for the DFBX "G" box is given in Figure 2.

3. Destination and Shipping Dates

The fabrication vendor shall load the feedboxes into the shipping crates after the requirements of the pre-shipping acceptance tests have been met. These requirements are outlined in the Acceptance Criteria Document (LBNL Engineering Specification M989). The fabrication vendor shall arrange for shipping of the crates directly to the following address:

CERN
CH-1211
Geneva, Switzerland
Attn.: Ranko Ostojic

The vendor shall select the appropriate mode of transport for each unit as permitted by the acceleration limits of the DFBX as well as the timing of fabrication completion such that the required delivery dates are met. The vendor may choose to ship more than one feedbox in the same shipment as long as each is crated separately. Upon arrival at CERN, each DFBX feedbox must again satisfy the acceptance requirements specified in M989.

4. Shipping Loads and Crate Performance Requirements

During handling and transport, the shipping crate and enclosed DFBX will be subject to both shock and vibratory accelerations. An analysis has been performed to determine the magnitude of acceleration in each coordinate direction that the feedboxes can tolerate. Details of the analyses can be found in LBNL Engineering Note M8043. The following requirements are based on the results of the analyses along with appropriate factors of safety:

- maximum vertical shock acceleration transmitted to feedbox: $\pm$5.0g
- maximum horizontal shock acceleration transmitted to feedbox: $\pm$2.0g

The specified limits are the net maximum allowable accelerations measured on the feedbox during transport. The shipping crate must isolate the DFBX from the actual external shipping accelerations which could be considerably higher.

The vendor shall design the shock and vibration isolation system such that a fully loaded crate has a primary (first) mode of oscillation >5 Hz and <10 Hz. Additionally, the crate must be designed to undergo a free drop from a height of 6 inches without transmitting more than the vertical shock limit of 5.0 g's to the feedbox. The feedbox shall be supported uniformly across its bottom surface within the crate. The jack mounting points must not be used to support the feedbox within the crate.

5. Preparation for Shipping

The Acceptance Criteria Document (Spec. M989) describes the procedures for backfilling of various DFBX components prior to shipping. Some additional preparation will be required in order to protect the pipes and bellows from being damaged by shock and vibration loads.

The vendor shall support any internal piping that is not fully restrained by means of added supports installed through the feedbox end flanges. The added restraints will be removed after shipping is complete. The D1, Q3, JC1 and JC2 flange caps used for acceptance testing are to include internal features to provide support for the ends of pipes that extend outside of the flanges. All other external piping must be restrained as appropriate. While the external connections to the current leads will not require additional support to withstand the shipping accelerations, protective covers or shields will be necessary to prevent handling damage during loading and unloading of the shipping crate.

6. Instrumentation

The vendor shall provide four RD298 Shocklog Tri-axial Recorders made by Lamerholm Fleming Ltd. for shock and vibration monitoring during transport of each crate. Two units are to be mounted on the DFBX box inside the shipping crate for redundancy. A second pair of redundant accelerometer systems will be located on the exterior of the shipping crates such that they are clearly visible and protected from damage during handling of the crate. Accelerometers may be reused on subsequent shipments as scheduling permits. The vendor shall provide LBNL with the accelerometer data records after each package has been delivered to CERN.

7. Packaging Features

The vendor shall incorporate the following features in the design of the DFBX crates in addition to providing the shock and vibration isolation as specified earlier in this document:

a) full enclosure on all sides of the feedbox
b) sufficient interior restraint to prevent the feedbox from shifting within the crate
c) feedbox to be supported only on the exterior surfaces of the 1.5" thick vacuum box
d) appropriate and clearly marked exterior features to allow tie down during transport and lifting by means of both a crane and a forklift
e) design of crate and lifting fixture (if used) shall be sized to allow lifting with a crane having a maximum hook height of 17 feet (5.2 meters)
f) provision for repeated access to the feedbox without significant damage occurring to the crate
g) protection from prolonged exposure to the weather without corrosion or other damage occurring to the DFBX
h) clear and obvious labels in English, Spanish and French indicating the presence of fragile contents as well as shock and vibration recording instruments
i) labels warning against tipping the crate from its normal position or stacking any items on top of it
j) extra interior space and restraints for any miscellaneous DFBX hardware (mounting jacks, etc.)
k) any welds used in the construction of the shipping crate must conform to AWS code as determined by an AWS certified weld inspector

The shipping crate design is to be evaluated in a preliminary design review by LBNL prior to fabrication. Any load testing performed by the vendor to verify the crate design shall be witnessed by an LBNL representative. Each feedbox and shipping crate will be inspected by an LBNL representative prior to being shipped. The fabricator shall be responsible for the ability of the crate to perform according to this specification, regardless of any implied approval by LBNL.

8. Acceptance Criteria

As previously indicated, each DFBX will be considered successfully delivered to CERN if all of the requirements listed in the Acceptance Criteria Document, represented by LBNL Engineering Note M989, have been satisfied. Furthermore, the transmitted shock load limits specified in this document must not have been exceeded as indicated by the accelerometer records. If any of the acceleration limits are exceeded, LBNL reserves the right to delay subsequent shipments until a full visual and mechanical checkout in addition to the specified acceptance testing is completed. The subject DFBX may still be accepted providing that the post-shipping tests and inspections do not reveal any damage to the hardware. Also, the vendor shall take any necessary steps to eliminate accelerations in excess of the limits of this document for all subsequent shipments.

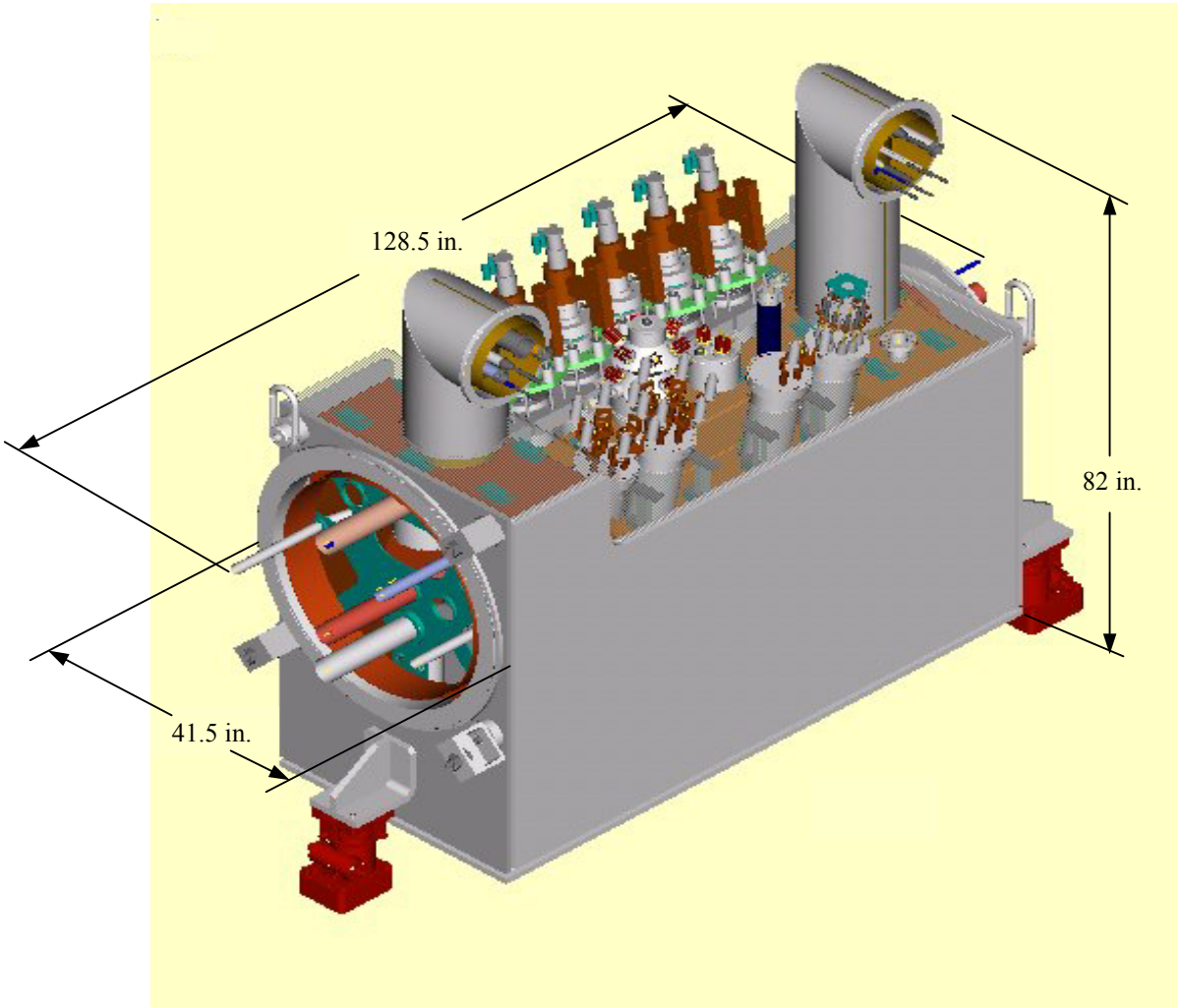
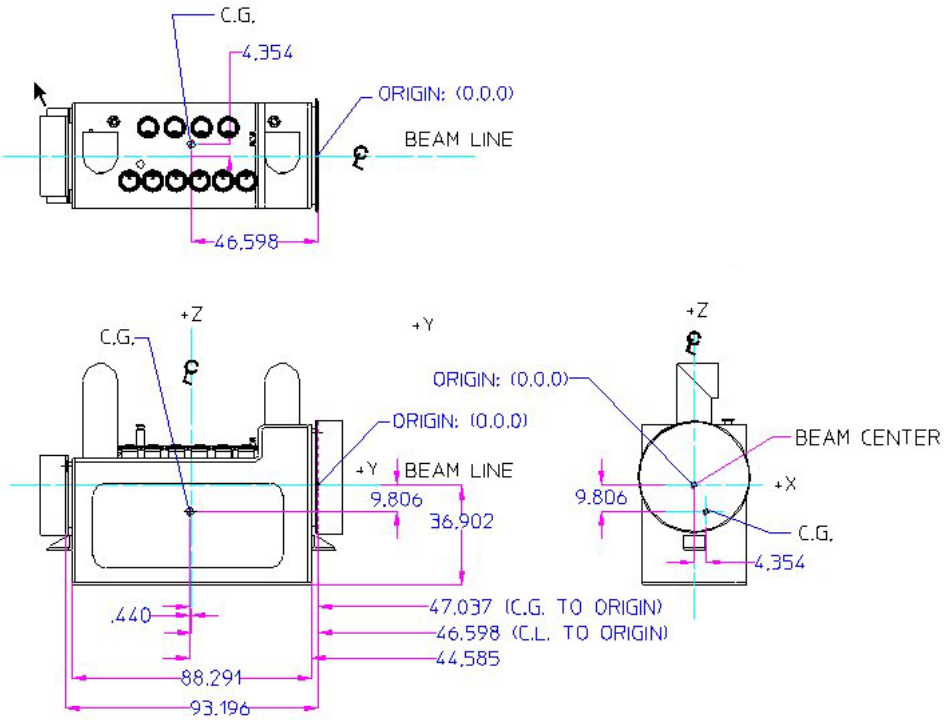
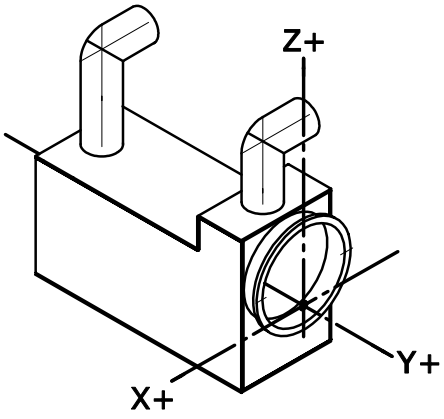


Figure 1. Illustration of the DFBX Assembly Showing Maximum Dimensions (jacks not included)





C.G. Location:

X = -4.354 in.
Y = -46.598 in.
Z= -9.806 in.

Figure 2. DFBX : Orthogonal Views and Center of Gravity Location